STRENGTH OF MATERIALS
Cylindrical Thin-Walled Pressure Vessel

Objective

The purpose of this exercise is to demonstrate the validity of the relationships for hoop stress and longitudinal stress using strain gage analysis and generalized Hooke's law. Theoretical verification of measured strains will be obtained using Mohr's circle of stress and Mohr's circle of strain.

Theory

A pressure vessel is described as thin-walled when the ratio of the wall thickness (t) to the radius (r) of the vessel is so small that the distribution of normal stress on a plane perpendicular to the surface of the shell is essentially uniform throughout the thickness of the shell. (Actually, this stress varies from a maximum value at the inside surface to a minimum value at the outside surface of the shell.) A vessel is generally classified as thin-walled if its radius is at least ten times larger than its wall thickness. The axial and hoop (circumferential) stress (σ_a and σ_h, respectively) due to internal pressure p are given by the following equations:

$$\sigma_a = \frac{pr}{2t} \qquad (1) \qquad\qquad \sigma_h = \frac{pr}{t} \qquad (2)$$

The strain in these two directions (ε_a and ε_h) are given by generalized Hooke's Law (where E is Young's modulus):

$$\varepsilon_a = \frac{\sigma_a}{E} - \nu\frac{\sigma_h}{E} \qquad (3) \qquad\qquad \varepsilon_h = \frac{\sigma_h}{E} - \nu\frac{\sigma_a}{E} \qquad (4)$$

Procedure

Six strain gages are mounted on the thin-walled cylinder apparatus to determine the strain at various locations when the cylinder is subjected to fluid pressure of 500 psi within. Gage orientations are shown in Figure 1 and strain is measured in the direction of the long axis of the gage.

Pump the cylinder to a pressure of 500 psi and maintain this pressure while the strain is recorded at the six gage locations. Repeat this process two times, average, and record the results in Table 1. Also complete Table 2 for a comparison of the results.

Calculate the theoretical hoop and axial stresses using Eqs. (1) and (2). Using the theoretical hoop and axial stresses, generalized Hooke's law and Mohr's circle of strain, calculate the strains that should be evaluated in each strain gage and record these results in Table 2.

For the same values of theoretical hoop and axial stresses use Mohr's circle for stress and generalized Hooke's Law to calculate the strains that should be evaluated in each strain gage and record these results in Table 3.

Pressure Vessel Data

The pressure vessel analyzed here has an inside radius (r) of 1.5 in., a wall thickness (t) of 0.125 in., and is made of aluminum with $E = 10.7 \times 10^6$ psi and $\nu = 0.31$.

Report

The report should be in the format specified by your instructor and should include Mohr's circle calculations using both the Mohr's circle of stress and the Mohr's circle of strain. The report should also include objectives, procedure, sample calculations, discussion of results and conclusions.

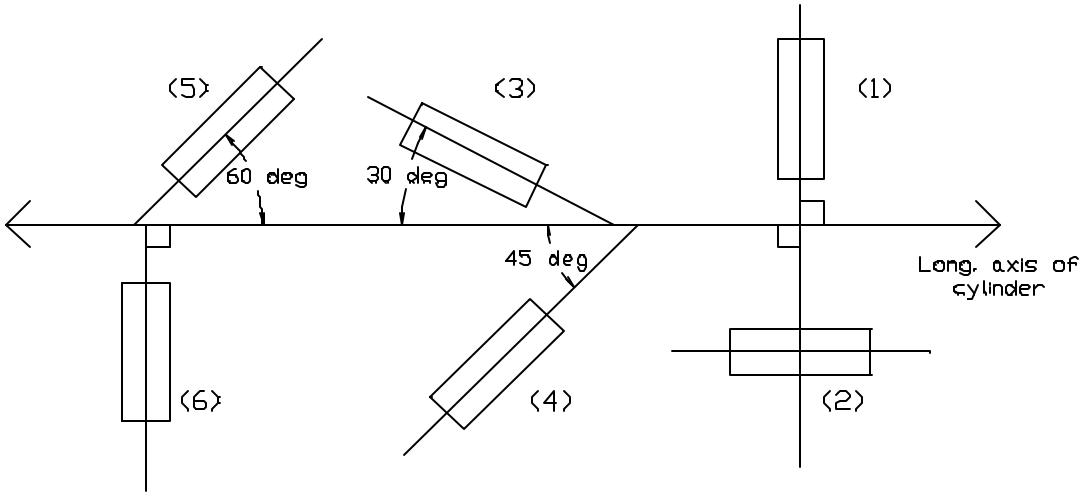

Figure 1 - Schematic of the gage orientations and numbering.

Raw Data

Table 1 - Experimental strains (pressure = 500 psi)

Gage	Strain (μ in/in) Data Set 1	Strain (μ in/in) Data Set 2	Average Strain (μ in/in)
1			
2			
3			
4			
5			
6			.

Summary of Results

Table 2 - Theoretical verification of measured strains using generalized Hooke's Law and Mohr's circle of strain.

	Gage (μ in/in)					
	1	2	3	4	5	6
Experimental Strain						
Theoretical Strain						
Percent Difference						

Table 3 - Theoretical verification of measured strains using Mohr's circle of stress and generalized Hooke's Law.

	Gage (μ in/in)					
	1	2	3	4	5	6
Experimental Strain						
Theoretical Strain						
Percent Difference						